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FEATURES OF A BODY OF ANORTHOSITE-GABBRO IN NORTHERN NEW YORK¹

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GENERAL RELATIONS OF THE ANORTHOSITE-GABBRO

The body of rock considered in this paper varies from true anorthosite, through anorthosite-gabbro, to true gabbro. It is four and one-third miles long, with a maximum width of one mile. It lies a little west of the central part of the Russell quadrangle in St. Lawrence County, New York (Fig. 1).

As far as could be determined, the rock immediately surrounding the gabbro is granite which is generally pink in color and carries only moderate amounts of dark minerals. The granite varies from medium grained to coarse grained, and from scarcely foliated to highly foliated. That the granite is younger than the anorthosite-gabbro is proved by the presence of both granite and granite-pegmatite dikes in the gabbro, and by the more or less intimate injection of portions of the borders of the gabbro by the granite. The best and most instructive exposures occur within the northern one-third of the area.

About twenty-five years ago Professor C. H. Smyth published a short paper² which is largely a microscopical petrographic description of a ledge of gabbro probably lying within the area of anorthosite-gabbro. It is the present purpose to rather fully discuss the megascopic and microscopic features, field relations, and origin of the remarkable lot of rocks which constitute facies of the body of anorthosite-gabbro and directly associated rocks covering several square miles.

VARIATIONS IN COMPOSITION

The whole mass of the rock of the area is called anorthosite-gabbro because it shows every possible gradation from true gabbro

¹ Published by permission of the state geologist of New York.

² C. H. Smyth, *Amer. Jour. Sci.*, 4th series, Vol. I (1896), pp. 273-81.

(light gray to dark gray) to almost pure plagioclase anorthosite (light gray to nearly white). In the northern portion of the area the light-gray anorthositic facies are most conspicuously developed, but they occur locally in all parts of the area.

In thin section under the microscope the feldspars of the gray to nearly black facies contain myriads of dustlike inclusions,

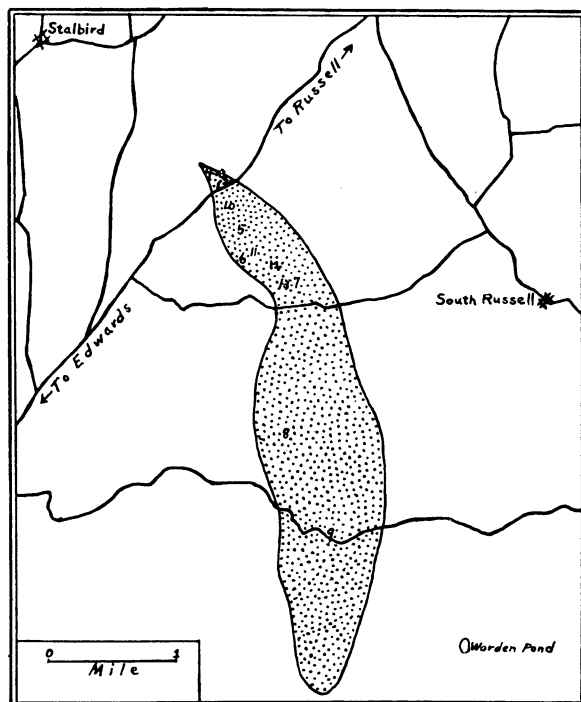


FIG. 1.—Sketch map of part of central St. Lawrence County, New York, showing the location of the body of anorthosite-gabbro. Numbers indicate localities referred to in the text.

probably ilmenite. No. 42 of Table I (see below) represents a thin section of a specimen of the typical very common dark-gray, medium-grained to moderately coarse-grained, non-foliated gabbro with ophitic texture from locality 9 (see Fig. 1). The labradorites, which range in length up to one-half an inch, are generally euhedral. All the pyroxenes (probably diallage) have narrow rims of hornblende around them, but some hornblende occurs either in small

clusters or as scattering grains. There is some very local granulation, especially of the feldspars.

No. 39 of the table represents a thin section of a light greenish-gray, medium-grained, moderately ophitic gabbro from locality 8. The andesine is much altered, mostly to scapolite. The pyroxene (probably diallage) is pale green to colorless. Tiny black inclusions in it are common. Most of the hornblende forms distinct granular rims around the pyroxenes, but a good deal of it is elsewhere interlocked with the pyroxenes. There is some granulation of the feldspars in local zones only.

No. 51 of the table is from a specimen of the very common dark-gray, non-foliated, medium-grained to fine-grained gabbro with ophitic texture from locality 7.

At locality 6 the main body of the rock is a medium-grained to moderately coarse-grained gabbro with a crude ophitic texture. The feldspar laths range up to three-fourths of an inch in length. No. 47 of the table shows the minerals contained in a thin section. Common green hornblende occurs mostly as narrow rims around both pyroxene and magnetite. Small inclusions of hornblende occur in the plagioclase. Granulation is lacking. Lying within the rock just described there is a zone of distinctly porphyritic, non-foliated gabbro about a rod wide, without sharp contacts. A hand specimen shows scattering, irregularly arranged, broad, dark laths of plagioclase up to one-half of an inch in length imbedded in a fine-grained dark-gray groundmass. No. 46 of the table shows the minerals observed in a thin section. Much of the feldspar has been altered, chiefly to scapolite. There is apparently no granulation, but considerable masses of fine granular hornblende, pyroxene, biotite, and plagioclase fill large spaces between, and cracks in, the feldspar phenocrysts. A good many grains of biotite, hornblende, and pyroxene are also irregularly scattered through the feldspars.

In a ledge at locality 1 most of the rock is a coarse-grained hornblende-rich facies of the gabbro. This rock is light gray, due to whiteness of the feldspars, which range in length from the merest fraction of an inch to several inches. Most of the feldspars are distinctly euhedral. A coarse ophitic texture is usually well

exhibited over the weathered surface. No. 57 of the table represents a thin section. The large euhedral crystals of plagioclase (chiefly labradorite) are generally fringed with rather clear granular scapolite, while their interiors are considerably decomposed. On one side this rock is moderately foliated, the feldspars being drawn out into crude parallelism. This foliated portion is not sharply separated from the rest of the rock. Within the foliated portion, and not sharply separated from it, there is a tongue or dikelike mass of gabbro very rich in dark minerals, chiefly hornblende.

TABLE I
MINERALS BY VOLUME PERCENTAGES IN THIN SECTIONS OF THE ANORTHOSITE-
GABBRO AND CLOSELY ASSOCIATED ROCKS

Slide Number	Localities Shown on Sketch Map	Labradorite	Andesine	Oligoclase to Labradorite	Andesine to Labradorite	Scapolite	Augite or Diallage	Hornblende	Biotite	Quartz	Chlorite	Magnetite	Pyrite	Hematite	Zircon	Apatite	Titanite	Enidote
39.....	8	66	.....	.....	.....	25	6	6	$\frac{1}{2}$	.....	Little	2	.....	.....	Little	.....	.....	.....
42.....	0	74	.....	.....	.....	16	5	5	$\frac{1}{2}$	.....	.....	2	$\frac{1}{2}$	.....	.....	.....	.....	.....
46.....	6	.....	.....	82	.....	7	7	7	4	.....	.....	.....	.....	.....	.....	.....	.....	.....
47.....	6	.....	.....	76	.....	15	3	13	.....	.....	.....	4	.....	.....	.....	$\frac{1}{2}$	.....	.....
51.....	7	.....	50	.....	.....	24	10	10	0	.....	.....	8	$\frac{1}{2}$	1 $\frac{1}{2}$	.....	.....	.....	.....
57.....	1	.....	64	.....	10	.....	25	25	$\frac{1}{2}$	.....	.....	1	.....	.....	.....	.....	.....	.....
56.....	1	.....	76	.....	.....	10	12 $\frac{1}{2}$	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	.....
58.....	1	.....	.....	59	.....	14	23	14	.....	.....	.....	Little	.....	.....	4	.....	.....	.....
59.....	1	46	.....	.....	.....	26	26	26	.....	.....	.....	.....	.....	.....	1	.....	.....	.....
52.....	7	.....	.....	.....	39	.....	43	.....	13	.....	.....	4 $\frac{1}{2}$	$\frac{1}{2}$	.....	.....	.....	.....	.....
49.....	5	.....	64	.....	35	.....	$\frac{1}{2}$	.....	.....	.....	.....	.....	.....	.....	Little	Little	$\frac{1}{2}$	.....

In the coarse-grained gabbro at locality 1, less than a rod from the rocks above described, there is a highly foliated zone or belt of very variable rocks about a yard wide. Much of this rock is fine grained, dark gray, highly foliated, and uniform in appearance, a thin section being represented by No. 51 of the table. There appears to be no true granulation. Another facies of this zone is a highly foliated, medium-grained, light-gray gabbro which in thin section is represented by No. 56 of the table. Still another facies consists of fine-grained, highly foliated, alternating bands of practically pure white plagioclase and gray gabbro, these bands varying in width from one-tenth of an inch to an inch or two. No. 58 of the table gives the minerals contained in a thin section of this third facies.

An important feature, excluding the dikes below described, is the close association of facies very different in composition. In some cases such facies are asymmetrically arranged, but more commonly they are in the form of more or less well-defined belts or zones which in some cases show fairly sharp boundaries, though they mostly grade into the adjacent facies. Such belts or zones commonly vary from a fraction of an inch to some yards or rods wide. The general effect is more or less well-defined local banded structures within the body of anorthosite-gabbro, especially in its northern portion. (See Fig. 2.)

VARIATIONS IN FOLIATION

Many portions of the anorthosite-gabbro, especially toward the north, exhibit more or less well-defined foliation. The greatest bulk of the rock is, however, practically devoid of such a structure. The non-foliated rock is mostly true gabbro, varying from light gray to very dark gray in color, medium grained to moderately coarse grained, generally with an ophitic texture. Some of the light-gray anorthosite-gabbro and anorthosite facies are also non-foliated. In many parts of the whole area there are gradations from facies which exhibit little foliation to others which are very highly foliated. As in the case of the variations in composition, so here the variations in degree of foliation generally occur as more or less well-defined belts or zones. Such belts commonly range in width from a few inches to some yards or rods. Highly foliated, moderately foliated, and non-foliated belts may lie adjacent to each other, in some cases with fairly sharp contacts, and in many cases with gradations from one into another. The variations in foliation are best exhibited in the northern portion of the area. In certain cases dark facies of the gabbro are so highly foliated that they look like hornblende schists. In other cases the rocks look like typical basic gneisses with alternating light and dark bands. Most of the anorthosite or gabbro shows moderate foliation due to a crudely parallel arrangement of the minerals, especially the dark minerals, without producing a banded effect. Figure 2 gives a fair idea of the variations in composition and foliation in a single small ledge.

An important feature of the foliation is the notable variation in strike within the body of anorthosite-gabbro. Ranges in strike



FIG. 2.—An exposure of anorthosite-gabbro showing notable local variations in composition and foliation. Just north of the northern road across the area.



FIG. 3.—White dikes rich in plagioclase and scapolite cutting anorthosite-gabbro, one-third of a mile south-southeast of the northern road.

from northeast to northwest have been observed. Notable variations also occur within relatively short distances, even within a few yards or rods.

VARIATIONS IN TEXTURE

As already stated, most of the rock, except toward the north, is a true gabbro varying from gray to very dark gray, the latter predominating. Such gabbro is medium grained to coarse grained, and it commonly possesses a fair to excellent ophitic texture. In the northern portion of the area most of the rock is a gray to light-gray, medium-grained to moderately coarse-grained anorthosite-gabbro varying to anorthosite which does not so commonly possess an ophitic texture. Local zones of light- to dark-gray anorthosite-gabbro and gabbro throughout the area are fine grained to medium grained and generally more or less highly foliated. In some local portions of the general mass almost perfectly euhedral crystals of plagioclase up to an inch long are set in a fine, granular ground-mass of hornblende and monoclinic pyroxene.

The great bulk of the dark-gray gabbro shows little or no granulation. The very light-gray anorthositic facies are commonly considerably granulated. Much of the white feldspar of the light-gray anorthosite-gabbro, especially in the northern portion of the area, shows more or less granulation. Non-foliated facies of the light-gray anorthositic gabbro exhibit little or no granulation of the dark minerals, but not uncommonly in the foliated facies the dark minerals as well as the feldspar are granulated.

CAUSES OF THE VARIATIONS IN COMPOSITION, STRUCTURE,
AND TEXTURE

It is believed that most, if not all, of the foregoing variations in composition, structure, and texture are primary features, in other words, that they developed under conditions of moderate pressure before or during the final consolidation of the anorthosite-gabbro magma. The main principles involved in the development of such features have been set forth by the writer in several recent papers¹ dealing with the origin of the foliation and banding of both the anorthosite and syenite-granite series of the Adirondack region.

¹ W. J. Miller, *Jour. Geol.*, Vol. XXIV (1916), pp. 600-619; *Science*, N.S., Vol. XLVIII (1918), pp. 560-63; *Bull. Geol. Soc. Amer.*, Vol. XXIX (1918), pp. 399-462.

A brief statement of the writer's explanation of the origin of the variations in composition, structure, and texture of the anorthosite-gabbro body will now be given.

1. It is believed that the intrusion of the anorthosite-gabbro magma was a complicated process of considerable duration. Much of the magma slowly solidified as a normal, moderately coarse-grained to medium-grained gabbro with an ophitic texture. Magmatic currents were practically absent from those portions.

2. In portions of the magma there were currents or movements sufficiently strong to cause the minerals, especially the earlier crystallized ones, to be drawn out into more or less perfect parallelism. This accounts for the gneissoid structure or foliation of considerable portions of the gabbro and anorthosite-gabbro, especially the medium-grained and fine-grained portions.

3. The more or less highly foliated structures of the many localized zones or belts of medium-grained to fine-grained rocks resulted from particularly active currents in those zones.

4. The more or less sharp alternations or variations in degree of foliation, and the notably varying strikes of the foliation throughout the area, are best explained as a result of locally developed differential magmatic movements or currents under conditions of not more than very moderate pressure. It seems impossible to account for such structures on the basis of pressure applied upon the body of anorthosite-gabbro after its final consolidation, first, because such pressure could not have caused notable foliation of certain narrow belts while adjacent masses were unaffected, especially in view of the fact that the highly foliated zones are not characterized by shearing or crushing (granulation), and, second, because any such pressure sufficiently strong to produce foliation must have been exerted in a single general direction with about equal force, and hence the sharp variations in strike of the foliation are left unaccounted for.

5. The variations in composition are the result of differentiation of the anorthosite-gabbro magma before or during its consolidation.

6. Those foliated zones or belts which show sharp variations in composition in layers ranging from nearly pure plagioclase to gabbro rich in ferro-magnesian minerals are the result either of

differentiation into such layers, probably accompanied by differential movements, during the intrusion, or of local intrusions of heterogeneous portions of the magma in which the differentiation took place before intrusion along local zones.

7. Certain local dike-like facies extra rich in ferromagnesian minerals, which are not sharply separated from the main mass of the anorthosite-gabbro and send dikelets into it, are basic differentiates from a lower level forced upward into the more normal mass which had already more nearly approached final consolidation.

8. The granulation of the feldspars in those portions of the foliated lighter-gray gabbro and anorthosite-gabbro in which the ferromagnesian minerals show little or no granulation is believed to have resulted mainly from movements in the magma before final consolidation, that is during or after the crystallization of the feldspars, but while the ferromagnesian minerals were still more or less liquid. In other words, we are here dealing with a protoclastic texture. Such pressure could not have been applied after complete consolidation of the magma because, if so, the dark minerals would also be granulated. Where the ferromagnesian minerals also show granulation, this probably resulted from magmatic movements just prior to final solidification, or from pressure upon solidified portions of the mass exerted by locally intruding portions of still liquid rock. The possibility is conceded, however, of the development of some granulation of this type by external application of moderate pressure upon the whole body of anorthosite-gabbro, but the localization of such granulation renders such an explanation less likely.

DARK DIKES RICH IN HORNBLLENDE AND SCAPOLITE

At locality 7 there is a fine display of rather remarkable dikes. The country rock is there mainly a medium-grained, dark-gray, rather typical, non-foliated gabbro with ophitic texture. No. 51 of the table gives the mineral content of a thin section.

Over an area of several acres the rock just described is cut most irregularly by a network of numerous dikes of dark-gray, highly foliated, fine-grained to medium-grained rocks consisting chiefly of scapolite and hornblende together with some quartz and

magnetite and a little pyrite. No. 52 of the table shows the simple but rather remarkable mineral content of a thin section of one of these dikes. The scapolite is clear and fresh in the form of irregular grains. The hornblende is the common variety with pleochroism ranging from dark green to greenish yellow. Nearly all the minerals are distinctly elongated parallel to the foliation. There seems to be no granulation. These dikes have more or less indefinite boundaries against the normal gabbro into which they fray out most irregularly. They seldom exceed a foot in width. The highly foliated structure of dikes arranged like these in normal gabbro cannot have resulted from pressure brought to bear upon the whole mass of rock after it had all become consolidated. It is evident that we are here dealing with a remarkable case of primary foliation developed to a high degree in small dikes before their final consolidation. The lack of sharp contacts points to the intrusion of the dike material into the gabbro while the latter was still hot, though nearly or quite consolidated.

In the light-gray anorthosite-gabbro of the northern portion of the area, some dark, hornblende-rich, well-foliated dike-like bands occur. In some cases the contacts are fairly sharp, and in others they are not. Most of these bands quite certainly represent intrusions into the still hot but nearly or quite solidified country rock, and their foliation is of primary origin. None of these bands show a network arrangement. Whether or not they, too, are rich in scapolite is not known.

WHITE DIKES RICH IN PLAGIOCLASE AND SCAPOLITE

At a number of localities white dikes were observed to cut the anorthosite-gabbro and gabbro. A good display of such dikes may be seen in a ledge at locality 5 (see Fig. 3). The main rock of the ledge is gray, medium-grained, well-foliated gabbro varying to anorthosite-gabbro. Several white dikes ranging in width from one to several inches cut across the foliation of the gabbro at high angles. These dikes, which are roughly parallel and traceable for a rod or more, contain a maximum of not more than a few per cent of dark minerals. They are fine grained with some scattering feldspars up to one-half an inch in length. Contacts against the

country rock are not very sharp. No. 49 of the table gives the mineral content of a thin section of the dike rock. Little or no granulation is shown. The scapolite, which is very clear and fresh, occurs mostly in the form of irregular grains as inclusions in the feldspar. Since the scapolite grains are variously oriented in the feldspar and their contacts are sharp, it is evident not only that the scapolite crystallized before the plagioclase, but also that it is not merely a decomposition product of the feldspar. Either the scapolite is of primary origin, or it somehow represents recrystallized material.

On a little hill at locality 10 several similar dikes were observed. Some of these show a moderate degree of foliation. Others occur here and there in the anorthosite-gabbro at localities 6, 7, 11, 12, and 13. Still others fill many of the cracks in the prominent zone of fractured and crushed anorthosite-gabbro described below.

On the one hand, the true dike character of these white rocks and their strike across the foliation of the country rock at high angles prove that they were intruded after the anorthosite-gabbro, which contains them, had almost or completely solidified. On the other hand, their lack of sharp contacts indicates that they were intruded while the anorthosite-gabbro was still hot enough to allow some merging of the dike materials with the walls. The dike material probably originated by differentiation in a still more or less liquid portion at a lower level and was then forced into fissures in a higher, cooler portion of the anorthosite-gabbro body.

The dikes are, according to this view, satellitic dikes of the anorthosite-gabbro.

HORNBLENDITE DIKES

These are remarkable dikes consisting of pure hornblende. Altogether in the northern one-third of the area of anorthosite-gabbro many dozens of the hornblendite dikes were observed. They are generally grouped in certain portions of the anorthosite-gabbro where it has been fractured. At locality 10 many cracks, commonly in the form of a network in the light-gray, moderately coarse-grained, little foliated gabbro, are filled with small dikes of moderately coarse-grained pure hornblende. Contacts of the

dikes are not sharp. At locality 5, close to the white dikes shown in Figure 3, the anorthosite-gabbro contains many roughly parallel



FIG. 4.—Dikes of hornblende filling curving cracks in anorthosite-gabbro, one-third of a mile south-southeast of the northern road.



FIG. 5.—Ledge of granite containing curving cracks filled with pyroxenite dikes on the left side, and nearly vertical cracks filled with pyroxene-rich pegmatite dikes on the right side. Close to the very northern end of the anorthosite-gabbro area.

curving cracks filled with small dikes of pure hornblende (see Fig. 4). Still farther south, especially at localities 7, 11, 12, and 13, more cracks are filled with hornblende dikes.

The hornblendite dikes are commonly from one-half an inch to one inch wide, and they are seldom traceable individually for more than a few yards or rods. They cut the anorthosite-gabbro in all directions, not uncommonly at high angles across its foliation. Contacts against the country rock are always sharp. The dike material is practically pure, common hornblende which, in the hand specimen, is greenish black where fresh, and dull green where weathered. The dikes are rather uniformly moderately coarse grained, the crystals usually varying in length from one-fifth of an inch to one inch. There is no suggestion of finer grain along the borders. Granulation is absent.

Many of the dikes occupy curving cracks in the anorthosite-gabbro as described below. In some such cases hornblendite dikes lie in rather sharp contact against dikes of nearly pure plagioclase anorthosite. On the southern face of the little hill at locality 10, several hornblendite dikes cut sharply across some branching, white, plagioclase-scapolite dikes, the latter in some cases being faulted where the hornblendite dikes cross.

Both the hornblendite dikes and the white dikes rich in plagioclase and scapolite are quite certainly late differentiates of the cooling anorthosite-gabbro magma at some depth below the present rock surface. They are in a real sense complementary dikes, the differentiated white-dike material having been forced upward into the nearly or quite consolidated, but still hot, anorthosite-gabbro, while the differentiated hornblendite was later forced upward into cracks in the relatively much cooler body of anorthosite-gabbro. This is in harmony with the lack of sharp contacts of the white dikes, and the sharpness of contacts of the hornblendite dikes.

In the discussion of this paper at the Boston meeting of the Geological Society, N. L. Bowen suggested that the fissures filled with hornblende might better be called veins instead of dikes. But, because they show no vein structure and are in almost every way like true dikes, the writer considers them to be dikes, probably in the category of pegmatites because of their coarseness of grain and lack of chilled borders. It is accordingly reasonable to believe that the hornblende was either in solution in a pegmatite

residue of the anorthosite-gabbro magma, or it was taken into solution by magmatic solvents during their passage through the anorthosite-gabbro after it was nearly or wholly consolidated but still hot. That the general rock mass was still hot during the intrusion of the hornblendite dikes is proved by the fact that still later minor intrusions, as distinct facies of the anorthosite-gabbro, took place. In any case we are dealing with magmatic intrusive material (hornblendite) which should be classed as dike rather than vein material.

FRACTURED AND CRUSHED ZONES

A remarkable zone or belt of fractured, and in part crushed, anorthosite-gabbro occurs near the northern end of the area. It strikes about north 60° west and extends partly across the northern road near the granite contact at locality 2. This fractured zone maintains a fairly uniform width of about one rod, and it is very clearly exposed across a great ledge of bare rock for approximately two hundred feet on the north side of the road. South of the road it shows much less. The main body of rock of this zone varies from nearly white anorthosite to light-gray anorthosite-gabbro. This zone is characterized throughout its length by a remarkable system of curving, roughly parallel cracks. In a sense the cracks are festooned one within the other. This system of cracks extends across the zone of fracturing rather than parallel with it. Fig. 6 gives a fairly good idea of the structure, though the foreshortening in the picture is strong. The description immediately following pertains to this photographed locality twelve or fifteen rods north of the road. Between the cracks the distances generally range from one to six or eight inches. Most of the cracks (now filled) are from one-fourth of an inch to two inches wide, but they vary considerably even within a few inches. A single crack is seldom traceable for more than five or six feet. The cracks are filled chiefly with rather fine-grained, nearly pure-white, plagioclase-rich material. The walls of the cracks are mostly exceedingly irregular, with multitudes of sharp indentations, usually less than an inch deep, into which the feldspar has been filled. In many cases the plagioclase-rich filling sends off small tongues or dikelets, rarely over a foot long, ending in fairly sharp points in the anorthosite-gabbro. Some of the filled cracks are

distinctly lenslike, up to a foot long. That the plagioclase-rich material was forced into the cracks in the form of dikes seems



FIG. 6.—A portion of the remarkably fractured zone of anorthosite-gabbro with its dikes in the northern portion of the area. About fifteen rods north of the northern road.



FIG. 7.—A local highly crushed portion of the prominent zone of fracturing in the anorthosite-gabbro. A few rods north of the northern road.

almost certain. Contacts of the dikes against the anorthosite-gabbro are generally fairly sharp. On the north side of the photographed locality (see left side of Fig. 6) a good many very small

dikes of hornblendite occur within the dikes of white plagioclase-rich material. These dikes of hornblendite are exactly like the ones above described. Lying in the midst of the fractured zone at this locality and parallel to its strike, there is a twenty-inch wide band of dark, highly foliated gabbro rich in ferromagnesian minerals (see Fig. 6). This band of dark gabbro cuts squarely across the curving, dike-filled cracks by sharp contact on one side and by moderately sharp contact on the other side. In the midst of the dark band and parallel to it there is a dike-like strip of white plagioclase-rich anorthosite several inches wide, separated into blocks by multiple faulting. These faults extend across the dike-filled fractures of the anorthosite-gabbro on one side. The dark band of gabbro with its faulted white strip is well shown in Figure 6.

The history of the features which occur at the locality just described is probably about as follows. The main mass of the anorthosite-gabbro now at the surface was intruded and nearly or completely solidified. Then it was subjected to a torsional strain, probably due to a moderate pressure externally applied, whereby the system of parallel curving cracks was developed. The cracks were filled with plagioclase-rich dike material forced upward as a differentiate from a lower level of still more or less liquid gabbro. Still later came the intrusion of the hornblendite dikes into some of the same cracks, this material also having been produced as a differentiate at a lower level. Distinctly later, the twenty-inch-wide band of dark gabbro rich in ferromagnesian minerals was intruded, this material also having been derived from a portion of the general gabbro mass which was still in a more or less liquid condition at a lower level. Then the small white dike was intruded into the band of dark gabbro. Finally, after the whole complicated mass of gabbro and anorthosite now at the surface was solidified, the band of dark gabbro with its small white dike and the adjacent rock on one side were subjected to multiple faulting on a small scale.

A local portion of the fractured zone lying a few rods north of the road exhibits a high degree of crushing. Figure 7 gives a fair idea of this locality. The rock is mostly a very light-gray

to nearly white anorthosite relatively free from dark minerals. The ledge contains thousands of rounded to subangular pieces of medium to coarse granular plagioclase-rich material imbedded in a matrix of distinctly finer-grained groundmass. Remnants of the system of parallel curving cracks are clearly visible in parts of the ledge as, for example, just above the hammer in the picture (Fig. 7). Evidently here, as well as in that part of the ledge farther west, the system of crudely parallel curving cracks was developed by moderate pressure (probably a torsional strain) after the magma was nearly or completely solidified, but under continued pressure the rock was mostly shattered into small fragments. It seems likely that considerable nearly pure anorthosite magma then invaded the shattered mass and that the rounding off of the fragments was probably partly due to the mechanical crushing and partly to magmatic corrosion.

Certain other portions of the anorthosite-gabbro also show multiple fracturing but on lesser scales as, for example, at localities 5, 7, and 12.

PEGMATITE DIKE RICH IN PYROXENE

A pegmatite dike of special interest occurs in the anorthosite-gabbro at locality 3. It cuts across the foliation of the gabbro in the form of a lens with a length of twenty-five feet and a maximum width of three feet. It sends off one distinct branch about a yard long into the gabbro. This dike consists mostly of feldspar (chiefly oligoclase) and green monoclinic pyroxene, together with 5 to 8 per cent of quartz, all in anhedral crystals commonly from one to several inches long. Nearly all the pyroxene occurs in very irregular segregation masses up to several feet across. Some of the quartz is associated with plagioclase, and some occurs within the pyroxene segregation masses. This dike lies in sharp contact against the anorthosite-gabbro except within a few feet of each end.

This pegmatite is believed to be an offshoot from the adjacent granite, the magma or magmatic juices of which, on their way through the gabbro, dissolved or digested materials (chiefly ferro-magnesian) from the gabbro, thus giving rise to the rather basic pyroxene-rich pegmatite. Because of the dissolving power of the

pegmatitic juices of magma, sharp contacts against the country rock would not be expected except where the magma had risen far enough to have lost its dissolving power. Further light is thrown upon the problem of the origin of this pegmatite rich in pyroxene in the discussion of the pyroxenite dikes (see below) which occur in the adjacent granite.

PYROXENITE DIKES IN THE ASSOCIATED GRANITE

Near the very northern end of the area of anorthosite-gabbro (locality 4), pyroxene-rich dikes cut a ledge of medium-grained, well-foliated, moderately hornblendic, pink granite close to its contact with the gabbro. Figure 5 shows the general relationships. On the left side curving parallel cracks in the granite are filled with dikes of pure to nearly pure, moderately coarse-grained, dark-green monoclinic pyroxene (apparently common augite). They contain only a few scattering crystals of orthoclase and quartz. None of these dikes is over an inch in width, and they all pinch out in the granite. Seven of them, up to two yards long, are perfectly arranged as a curved series one above the other in the face of the ledge. They show sharp contacts, and they cut across the foliation of the granite at high angles. On the right side (see Fig. 5) there are five or six coarser, crudely parallel, nearly vertical dikes, up to several inches each in width, in sharp contact with the granite. Crystals range up to two inches across. These dikes contain scattering crystals of orthoclase and quartz, but never more than 10 per cent. Between the two sets of dikes just described there is an irregular mass of very coarse pegmatite with crystals of quartz, orthoclase, and pyroxene up to six inches in length, but here the pyroxene is subordinate in amount. This mass shows only moderately sharp contacts against the granite.

It seems most probable that the pyroxene of both the pure pyroxene and pyroxene-rich pegmatite dikes was derived from the anorthosite-gabbro. Where the magma or juices passed through the gabbro, the pyroxene is believed to represent dissolved or digested and recrystallized ferromagnesian material.

It is important to bear in mind that the dikes of pure pyroxenite, as well as the dikes of hornblendite above described, are examples

of almost perfect mono-mineralic dikes. The pyroxenite dikes quite certainly, and the hornblendite dikes most probably, are of pegmatitic, magmatic origin, the magmatic solvent or solvents (probably largely water) having disappeared during the crystallization. In conclusion it is suggested that mono-mineralic dikes like the pyroxenite and hornblendite above described should not necessarily, as Bowen¹ reasons, be excluded from the category of intrusive rocks. Is it not true that all active magmas are more or less rich in mineralizers, and is it not further an open question as to whether any magma can remain active, that is, still possess an intrusive power, after its mineralizers have all disappeared? Pegmatitic magmas of relatively early origin in their parent-rock are probably such powerful agents of intrusion and even of injection because of their richness in mineralizers. Does not the argument that no rock consisting of but one mineral could ever have existed as an intrusive magma, because at least one mineral must act as a solvent and another as a solute, disregard the perfectly plausible possibility of a single substance dissolved in some solvent which itself may not crystallize along with the dissolved material?

¹ N. L. Bowen, *Jour. Geol.*, Vol. XXV (1917), pp. 218, 235-36, 242-43.